REMARKS

Claims 1-51 are pending in the subject application. Of those claims, claims 17-19, 23-25, 28-35 and 49-51 are withdrawn as a result of restriction requirements. The withdrawn claims are hereby canceled without prejudice to the filing of one or more divisional applications.

Remaining claims 1-16, 20-22, 26-27 and 36-48 are rejected. More particularly, the Patent Office rejects claims 1, 8, 12-16, 20, 26, 27, 36-37, 39, 41 and 43-48 under 35 USC § 103(a) as being unpatentable over US Patent 5,863,493 to Achari et al. (Achari et al.) or JP 200052083 (JP '083) in view of US Patent 5,527,628 to Anderson et al. (Anderson et al.) and further in view of US Patent 5,520,752 to Lucey, Jr. et al. (Lucey, Jr. et al.) and US 2002/010106528 to Jin et al. (Jin et al.). Lastly, the Patent Office rejects claims 2-7, 9-11, 21-22, 38-40 and 42 under 35 USC § 103(a) as being unpatentable over the above references in further view of US 2003/0219623 to Kao et al. (Kao et al.).

The foregoing rejections are respectfully disagreed with, and are traversed below.

Achari et al. disclose electrical solder compositions having, in weight percent, between 91.5-96.5% Sn, 2-5% Ag, 0.1-3%Ni, and 0-2.9% Cu, and having a microstructure with uniformly dispersed fine grains of Sn-Ni, Sn-Cu and Sn-Cu-Ni intermetallic phases.

Achari et al. thus relate to a different microstructure than that of the subject claims. Achari et al. do not disclose or suggest an interface between the claimed solder and substrate consisting of a composite structure without scallop formation and including Sn islands.

As disclosed in Applicants' specification at page 1, excessive growth of Cu-Sn intermetallics may threaten packaging reliability. It is known that Cu-Sn intermetallics can undergo instability resulting in rough interface morphology, which adds more intermetallics to solder joints. As intermetallics are brittle in nature, such a microstructure may weaken the resistance of solder joints against failure by mechanical shock and fatigue.

As further disclosed at page 3 of Applicants' specification, the presence of Applicants' composite layer at the interface can advantageously act as a buffer for further reaction. Thus, this formation can be beneficial in increasing the shelf-life of printed circuit board components.

The Examiner states at page 4 of the Action that the "transitional expression 'having' in instant claims do not exclude microstructures that are disclosed in Achari." Applicants note that the independent claims have been further clarified to specify an intermetallic interface "consisting of" the claimed composite structure.

In view of the foregoing, the Examiner's rejections based upon Achari et al. should be reconsidered and withdrawn.

Nor is Applicants' claimed solder or joint disclosed or suggested by JP '083. JP '083 discloses solders of a particular composition and interface microstructure: Sn alloys containing, in weight percent, 0.5-5.0% Ag, 0.3-10.0% Au, and optionally 0.1-2.0% Cu and/or less than or equal to 0.5% P or Ga; Page 4 of the provided translation of JP '083 discloses that the interface of a conductor and solder was the normal reaction layer of Cu_3Sn/Cu_6Sn_5.

JP '083 does not disclose or suggest Applicants' claimed solder or joint including an interface between the solder and substrate consisting of a composite structure without scallop formation and including Sn islands. Nor does this reference disclose or suggest, as claimed by Applicants, the particular Pb free solder or joint comprising the defined additive element in an amount effective to form the particularly claimed interface.

The addition of Anderson et al., Lucey, Jr. et al., Jin et al. and Kao et al., alone or in combination, does not cure the shortcomings of the above reference for at least the following reasons.

Anderson et al. disclose a Pb free solder including a ternary eutectic composition consisting essentially of, in approximate weight percent, 96.3% Sn, 4.7% Ag and 1.7% Cu. As described at column 2 of Anderson et al., disclosed is a microstructure including beta Sn phase and at least two different intermetallic compounds distributed in the beta Sn phase, one compound including Cu and Sn and another compound including Ag and Sn. As further disclosed at column 6, the solder joint has a solidified ternary microstructure comprising beta Sn phase and at least two different, relatively hard intermetallic compounds, one compound including Cu and Sn (e.g. Cu-rich Cu_6Sn_5) and another compound including Ag and Sn (e.g. Ag rich Ag_3Sn) distributed uniformly in the beta Sn phase. Figs. 3a-3b show the solder joint produced by the afore-mentioned ternary eutectic solder.

Anderson et al. do not disclose or suggest an interface between the claimed solder and substrate consisting of a composite structure without scallop formation and including Sn islands, as claimed by Applicants. Nor does this reference disclose or suggest, as claimed by Applicants, the particular Pb free solder or joint comprising the defined additive element in an amount effective to form the particularly claimed interface. Anderson et al. relate to a different composition and microstructure than that of the subject claims.

As disclosed at page 2 of Applicants' specification the modified Sn-Ag-Cu Pb free solder alloy of Anderson et al. retains a fine, uniform microstructure, which may not be optimum for the increasingly demanding environments of Pb free solders. Thus, the skilled artisan would not be motivated to look to Anderson et al. for guidance in attempting to arrive at the subject claims, including the claimed distinct microstructure, nor would the artisan be motivated to combine Anderson et al. with the other cited references.

Lucey, Jr. et al. disclose particular Pb free solder alloy components selected from the group consisting of Sn-Ag-In, Sn-Ag-In-Bi, Sin-Ag-Bi, and Sn-Ag-Bi-Cu, and an intermetallic filler composition. Jin et al. disclose a method for fabricating a reactive solder or braze including forming a metallic matrix with an interior region and surface regions by actively providing a higher concentration of reactive atoms to the interior region than to the surface region. Neither of these references, whether viewed alone or in combination with the afore-cited references, discloses or suggests Applicants' particularly claimed interface.

Kao et al. disclose a solder joint having a Cu element contained therein, and by controlling the concentration of Cu in the solder a more protective reaction product at the interface between the solder joint and the Ni layer of the contact region is selected to form so as to reduce the consumption rate of the Ni layer. Kao et al. do not control an additive element selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof to form an intermetallic interface between the solder and a substrate, wherein the intermetallic interface consists of a composite structure without scallop formation and including Sn islands. Kao et al. are concerned with the application of a Ni layer, in contrast to the subject claims.

It is asserted that there is no teaching, suggestion or motivation that would lead one of ordinary skill in the art seeking to develop that which Applicants claim to combine and modify the teachings of the afore-cited references in an attempt to arrive at the subject claims. It is respectfully asserted that the TSM (teaching, suggestion, motivation) test provides helpful insights into the nonobviousness of the subject claims and there is no reason that would have led the skilled artisan to combine and modify the afore-referenced art in a particular manner in an attempt to arrive at the subject claims.

Moreover, as described at page 17 of the subject application, Applicants' composite interface microstructure that includes a finely dispersed ductile (βSn) phase can add an additional benefit to the solder reliability. One of the weakest links in a solder joint is the intermetallic layer at the interface. With fine dispersion of (βSn) phase in the matrix, the fracture toughness and thus fatigue resistance of the layer can be enhanced.

Fatigue testing results are also described at page 19 of the subject application further demonstrating Applicants' superior results. As described therein, Fig. 10 advantageously demonstrates that lifetime of the composite IMC sample (1.5Au-ACS in this example) is longer than that of scallop IMC sample (ACS & 0.25Au-ACS). Accordingly, reliability of the solder joint may be improved by forming the composite IMC structure in the interface.

Further advantages of Applicants' composite layer are described at page 20 of the subject application. For example, as described therein, the composite layer in a solder joint will also suppress the further growth of intermetallic phases.

Thus, in an objective analysis considering the scope and content of the afore-cited art, the level of ordinary skill in the art, the differences between the claimed invention and the cited art, and objective evidence of nonobviousness, as described above, it is respectfully asserted that the Examiner's obviousness rejections should be reconsidered and withdrawn.

All issues having been addressed, the subject application is believed to be in condition for immediate allowance as no new issues requiring a further search are raised. Accordingly, such favorable action is earnestly solicited. In view of the foregoing, the Examiner is respectfully requested to enter the Amendment, withdraw the outstanding rejections and pass the application to issuance.

A call to the undersigned attorney at the telephone number listed below would be appreciated should the Examiner have any questions, or believe that a discussion would advance the prosecution of the subject application.

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